UNDERWATER PLATFORMS FOR CHEMICAL DETECTION

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ABSTRACT

Chemical detection underwater is playing increasingly important roles for both military and environmental applications. Use of unmanned underwater vehicles as sensor platforms allow extended ranges and greater area coverage with minimal risk to personnel and high-value assets. There are a variety of underwater platform types available including remotely operated vehicles (ROVs), autonomous underwater vehicles (AUVs), and crawlers. The benefits and tradeoffs of each platform type will be discussed with regard to the specific mission and environments. ROVs are the most mature of the platforms, with a wide range of systems in use in the Fleet and commercially. AUVs are becoming available and will provide extended capabilities in the future. State of the art systems and directions will be presented.

OVERVIEW

Why Chemical Detection?

There are a wide variety of chemical detection missions, all with their own specific platform and sensor requirements. Chemical detection is increasingly of interest to military applications. The Office of Naval Research *Chemical Detection in the Marine Environment (CSME)* program is investigating the development and use of chemical sensors for the detection and localization of unexploded ordnance. Other potential uses include the detection and assessment of chemical agents such as those used in chemical warfare.

Environmental uses are also increasing. Detection of pollutants and the ability to track them to their source are key to improving our water quality. Detection of petro-chemicals may aid in both the search for oil and the correction of leaks before they reach catastrophic proportions. Understanding chemical cycles in the aquatic and marine environments can lead to improved water management.

Why Vehicles?

Use of unmanned vehicles as sensor platforms allow extended ranges and more efficient are coverage than with manned systems. Vehicles can often penetrate areas not accessible by boats or land-based systems. For many military applications, use of vehicles can allow low-observable operable, thus minimizing risk to personnel or high value assets.

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PLATFORM DETERMINATION

In order to evaluate the suitability of a platform, there have to be some criteria. In the case of chemical detection, these fall into two main categories: those driven by the mission operational requirements and those driven by the data to be collected.

Mission Requirements

Mission-driven criteria include such items as the range to be covered, the time available, and the standoff distance from the operators. These in turn drive the accuracy and sensitivity required by the vehicle and the sensors it carries. Many of the technology driven criteria are closely tied in with the mission requirements, with many tradeoffs to be made between them. For example, the overall mission time is generally driven by the power source, with improvements power efficiency largely reflected in improvements in length of mission. Similarly, the payload capacity of a vehicle is limited by the full range of technological constraints: weight, size, power available, and communications modes. Generally speaking, smaller, smarter, and longer lasting are all considered advantages when it comes to vehicle systems.

Data Requirements

The sensors used and the types of data to be collected also drive the selection of the platform. Items such as platform stability, minimum speed, and the ability to closely and accurately locate a target are all important for effective use of chemical sensors. The collection of auxiliary data is also key for the effective use of a vehicle-based sensor system. Data items such as precise location, depth, time, temperature, and other environmental factors may all play critical roles in the interpretation and use of the data. Figure 1 shows a sample data plot from the REMUS vehicle, combining both chemical sensor data and location data, showing the distribution of a rhodamine dye plume.

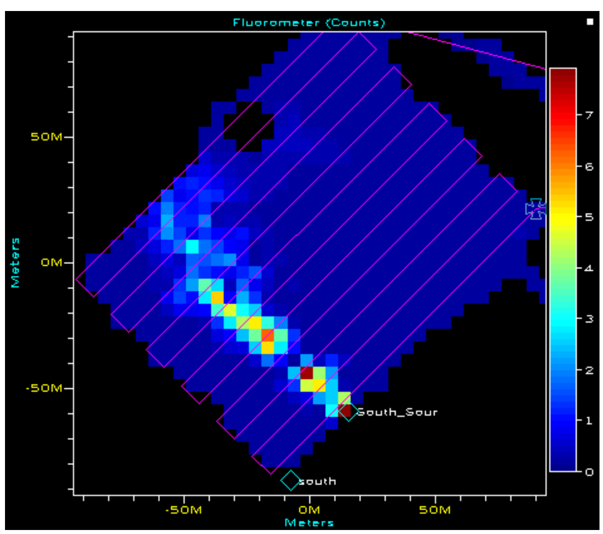

Figure 1: REMUS data plot showing location of rhodamine dye plume

REMOTELY OPERATED VEHICLE (ROV) PLATFORMS

Description

Remotely operated vehicles (ROVs) operate directly via a real-time communication link, which can be wire, fiber-optic, or radio controlled. They are a mature technology proven in the field for both military and commercial applications. The most common ROVs are those operated via a hard-wire or fiber-optic tether, connected directly to the operator on the surface.

Existing Systems

ROVs are used in navies around the world for mine countermeasures (MCM), with over 20 different types currently employed. Systems in the US Fleet include the Mine Neutralization System (AN-SLQ48), used for the identification and neutralization of previously detected mine-like objects (MLO). Commercially, there are upwards of 200 different models available, ranging from small observation systems (<20 pounds) to large heavy-duty work systems (>15,000 pounds). There are a number of specialized ROVs available for varied environments such as pipelines, ship hulls, and power plants. R/F controlled vehicle allows real time control and extended range without the constraints of a hard-wire tether. Figure 2 shows a variety of ROVs available today.

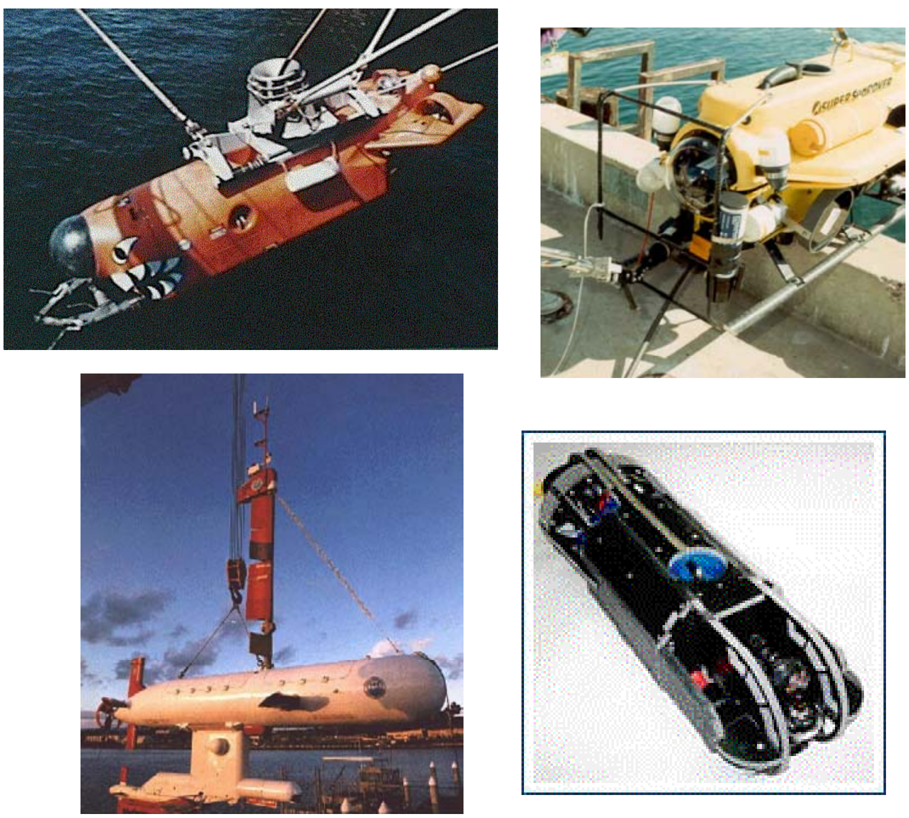

Figure 2: A ROV sampler (clockwise from upper left): Mine Neutralization System, SeaROVER, Pipeliner, and R/F controlled Dolphin

AUTONOMOUS UNDERWATER VEHICLE (AUV) PLATFORMS

Description

AUVs, also know as unmanned underwater vehicles (UUVs) operate independently or with minimal supervisory control. They must be able to perform pre-programmed missions, collecting sensor data, then either transmit the data or are recovered and the data downloaded. With no hard tether, AUVs provide greater range and flexibility than ROVS.

Existing Systems

Autonomous underwater vehicles (AUVs) have now come of age and are on the threshold of playing key roles in commercial, scientific, and military missions. Over 80 systems are operational worldwide, with a dozen available commercially. AUVs are being used on a near-routine basis to perform bathymetric surveys and collect oceanographic data. More specialized systems have been used successfully to perform deep ocean search, in-situ oceanographic measurements, and precision mapping. AUV systems are being introduced to the Fleet for submarine based mine-countermeasures: the Nearterm Mine Reconnaissance System in 1999, and the Longterm Mine Reconnaissance System slated for 2003. Smaller scale systems such as the Semi Autonomous Hydrographic Reconnaissance Vehicle (SAHRV) and CETUS are being developed for MCM and EOD tasks as well. Other vehicle types are being developed to operate in difficult environments, such as the surf zone. Crawling vehicles such as IS Robotics Ariel and FETCH systems have been demonstrated, and show potential for future development and use.

Figure 3: An AUV sampler: Nearterm Mine Reconnaissance System, CETUS, REMUS

FUTURE TRENDS

Comparisons and Tradeoffs

The type of vehicle to be used in any particular circumstance is intimately tied to both the functions it is to perform and the environment it must perform in. While small size is generally an asset, it is generally a tradeoff with both the length of mission and amount of payload required. Maneuverability is important for precision sensor work, but it is usually at the expense of long range, streamlining of the vehicle. Use of a tethered vehicle confers many advantages in terms of bandwidth, control, and power available, but it is untenable for extended range missions. Environment also plays a key role- AUVs can operate effectively in open areas, but do not yet have the ability to operate independently in complex, obstructed environments such as harbors. Clearly the mission must be understood in its entirety in order to choose an appropriate platform.

Future Trends

It is entirely feasible to outfit an ROV to perform chemical detection today, given an appropriate sensor. As the operator is directly in the loop, an ROV is well suited to serve as a testbed for underwater sensors that may later be incorporated into more autonomous systems. Many of the current operational AUVs could also be outfitted with a chemical sensing capability in addition to the other sensors carried. Looking forward, they can be tailored to accommodate the specific requirements for the chemical sensing mission. This includes larger scale systems such as the Long Term Mine Reconnaissance System which has the potential of carrying additional sensors, as well as the use of multiple, smaller systems such as the SAHRV. Control algorithms should be developed to make use of the combined capabilities of the sensor and vehicle platform, in order to provide more efficient data collection. These might include the development of multiple vehicle systems, as well as more intelligent single platforms.

Underwater platforms and their associated technologies will play an essential role for chemical detection. It will continue to increase with the development of more capable autonomous and multiple vehicle systems.

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